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Development and Validation of an Enhanced NROTC Selection System

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The Naval Reserve Officer Training Corps (NROTC) selection system, in use since 1987, has been helpful in predicting college grade point average, naval aptitude grades, and naval science grades. In recent years, the Navy's desire to increase the number of individuals graduating with engineering or science degrees has made revision to the current selection composite necessary. Development of the new composite entailed the evaluation of alternative predictor composites and the addition of a new criterion (i.e., an individual's final major). While these composites were designed to improve prediction of all criteria, there was particular emphasis on predicting technical major. Multiple regression was used to optimally weight academic ability, high school performance, vocational interest, engineering/science interests, background characteristics, and personal attributes. The revised composite contained all the predictors except for the engineering/science scale. A separate expectancy table was developed for evaluating an individual's engineering/science score. The new selection composite increased the ability to predict technical major over that of the current selection composite without decreasing the ability to predict the remaining three criteria.

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FOREWORD

This effort was conducted under the sponsorship of the Office of Chief of Naval Research (ONT-222), within program element 0602233N, project task RM33M20.05 Integrating Officer Selection Systems.

The present report describes the development of a new selection composite and compares its usefulness to that of other selection systems that were either proposed or formerly developed. Development of the new selection composite entailed the evaluation of several predictor composites and the addition of a new criterion measure (i.e., an individual's final major).

The authors would like to express their appreciation to CDR Bob Hawkins, Idell Neumann, and Anne Wahrenbrock for their help in completing this project.

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Prior Publications:

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SUMMARY

Problem

The current Naval Reserve Officers Training Corps (NROTC) selection system has been helpful in predicting three criteria: college grade point average (GPA), grade point average in naval science courses (NSG), and performance on nonacademic military aspects of the NROTC program (APT). In recent years, the Navy's desire to increase the number of individuals who graduate with engineering or science degrees has resulted in a need to modify the NROTC selection system so that a fourth criterion can also be predicted. The additional criterion is an applicant's likelihood of selecting a technical major (TECH).

Objective

The purpose of the present research was to develop a new selection system that would simultaneously consider the four criteria. Comparisons among new/experimental and previously developed selection composites were performed to (1) understand how adding the fourth criterion impacted the usefulness of the selection system when predicting each of the four criteria individually and (2) identify the optimum selection system--to be named the 1989 Quality Index (QI-89).

Approach

Selection composites were developed through a multi-step process. Initially, a separate multiple regression equation was computed to predict each of the four criteria. In each case, the equation contained six predictors: Scholastic Aptitude Test Mathematics and Verbal (SATM and SATV, respectively) scores, peer-relative high school performance (HSR), an interviewer's ratings (INTER), vocational interest scores related to whether an applicant would remain in the Navy at least 1 year past the minimum obligated service (SCII), scores from a biodata scale that predicted who would complete the NROTC program (BQ), and scores on an interest scale that was designed to identify applicants with engineering and science interests (ES). Next, the four weights for each predictor were mathematically combined to derive a single weight for each predictor. Finally, the predictor weights were combined to construct new/experimental selection composites that would be predictive of multiple criteria. Other selection composites were constructed using the weights derived in previous research.

Results and Conclusions

1. Most of the multiple-criterion predictor composites resulted in cross-validities of a similar magnitude when GPA and NSG were predicted. When TECH was predicted, the cross-validities for the predictor composites varied a great deal. As expected, the new/experimental composites that included TECH as a criterion were more valid for predicting TECH than were the previously developed predictor composites without TECH. All composites (including the composites specifically designed to predict APT) resulted in low cross-validities when APT was predicted.

2. Regardless of whether SATM and SATV were weighted optimally, equally, or in a ratio of 70 percent to 30 percent, the cross-validities were similar when predicting GPA and NSG. Composites that weighted SATM and SATV either optimally or 70 percent to 30 percent were, however, more valid for predicting TECH. The latter findings were expected since SATM predicted TECH better than did SATV.

3. Excluding the BQ from one of the new experimental composites had little impact on the cross-validities for any criterion.

4. Overall, the QI-89 selection system predicted GPA, NSG, and APT as well as or slightly better than the other predictor composites. The QI-89 can also be used in conjunction with the ES interest measure to influence the proportion of NROTC scholarship recipients choosing technical majors.

Recommendations

1. Chief of Naval Education and Training (CNET) should use the QI-89 and the ES scale as aids in selecting future NROTC scholarship recipients.

2. CNET should reevaluate the QI-89 as component predictors are modified and improved.

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INTRODUCTION

Background

Each year, the Naval Reserve Officer Training Corps (NROTC) receives approximately 45,000 inquiries regarding its scholarship program. Nearly 12,000 of the individuals contacting NROTC for information follow up their initial requests with applications for one of approximately 1,500 four-year college scholarships. The scholarships provide selectees with reimbursement for tuition, textbooks, and instructional fees. A subsistence allowance of $100 per month (for a maximum of 40 months) and pay for summer training periods are also provided to all persons awarded NROTC scholarships. A selectee, if accepted by the college, becomes a member of one of the 67 NROTC units that service 192 colleges and universities located nationwide. Upon graduation from the NROTC program and the college/university, scholarship recipients are commissioned as ensigns in the U.S. Navy and must serve a minimum of 4 years on active duty.

When determining who will receive NROTC scholarships, selection boards must synthesize a great deal of applicant information. To qualify for an NROTC scholarship, an applicant must have scored well on a series of variables that are used to predict a variety of performance criteria: college grade point average (GPA), naval aptitude grades (APT), and naval science grades (NSG). Especially important to this study are six academic and personal factors: Scholastic Aptitude Test-Verbal (SATV), Scholastic Aptitude Test-Math (SATM), high school class rating (HSR), an interviewer's ratings (INTER), the career-tenure scale developed from the Strong-Campbell Interest Inventory (SCII), and an NROTC-tenure scale developed from the Background Questionnaire (BQ).

In 1979, Neumann and Abrahams (1979) combined these variables to produce a composite called the Overall Index (OI). To compute that index, percentage points were assigned to each predictor. SATM and SATV together received 20 percent of the weight in the OI; HSR, 40 percent; INTER, 10 percent; and SCII and BQ together, 30 percent. Although the OI was helpful in predicting several performance criteria, Mattson, Neumann, and Abrahams (1986) sought improvements by developing a regression-based selection composite. Their composite uses multiple regression techniques to optimally weight both academic and personal variables to predict several performance criteria for individuals entering NROTC in 1979 and 1980. As a result of that study, the 1987 Quality Index (QI-87) was adopted. The QI-87 optimally weighted five factors: the sum of SATV and SATM, HSR, INTER, SCII, and BQ and resulted in an increased ability to predict all the performance criteria over that of the OI.

Problem

The current NROTC selection system, in use since 1987, has been helpful in predicting several performance criteria. In recent years, however, the Navy's desire to increase the number of individuals graduating with a technical degree (i.e., engineering or science) has made revisions to the current selection composite necessary. In the past, the selection composite has been used largely to predict academic (e.g., grade point average), and military performance criteria (e.g., naval aptitude grades). The current composite does not estimate an individual's likelihood of selecting a technical major.

Objective

The purpose of the present research was to develop a new selection composite that would simultaneously predict academic and military performance as well as technical major. To accomplish this goal, several new predictor composites that were designed to predict all criteria were developed. Comparisons were made among these composites and the previous NROTC selection composite to identify an optimum selection system.

APPROACH

Sample

The sample consisted of all 6,609 individuals who had entered NROTC from 1983 to 1987 and completed at least one semester/quarter of the program. Men comprised 96.5 percent of the sample, and 92.6 percent of the candidates were nonminorities. All of the individuals included in the sample had received 4-year NROTC scholarships (versus 1-year, 2-year, or 3-year scholarships); had complete data on GPA, APT, NSG, and all seven predictors; were Navy (versus Marine) option; and had a selection code of principal selectee, early select, alternate best, or alternate middle.

Predictors

Seven predictors were used to develop the selection composites.

SATV or American College Test (ACT) Verbal-equivalent

This score represents the verbal aptitude of the individual as measured by a standardized test designed for college admissions and scholarship awards. If an individual took the test(s) on multiple occasions, the highest score was used in the analyses. ACT verbal scores were translated to equivalent SATV scores using a recently developed conversion table (Owens-Kurtz, Borman, Gialluca, Abrahams, & Mattson, 1989).

SATM or ACT Math-equivalent

SATM parallels SATV except that it represents quantitative aptitude.

HSR

This variable is derived via a two-step procedure. First, each individual's percentile rank is determined using the following formula:

$$\text{Percentile Rank} = \frac{(\text{Rank in Class} \times 2) - 1}{\text{Class Size} \times 2}$$

Second, the resulting percentile rank is converted to an equivalent HSR using the conversion table (Navy Recruiting Command, 11-31.2, 1988) shown in Table 1. This second step is needed to lessen the effect of the negatively skewed distribution of percentile ranks (i.e., most of the students graduated in the upper percentiles of their high schools). HSR values can range from 0 to 100 in increments of 10.

Table 1

High School Record (HSR) Ratings and Equivalent Percentiles

HSR	Equivalent Percentile Rank
100	99 and up
90	97-98
80	95-96
70	89-94
60	81-88
50	70-80
40	56-69
30	42-55
20	26-41
10	10-25
0	9 and below

INTER

During 15-minute interviews, naval officers rate the applicants on several factors important to a career as a naval officer (e.g., appearance, poise, oral communication, leadership potential, motivation, and the officer's willingness to have the individual serve under his/her command). Based on the officers' ratings, individuals are assigned an overall rating of very high (1) to very poor (5). To stay consistent with other variables, this scale was reverse scored before it was weighted for inclusion in a composite.

SCII

This scale was designed to predict officer retention for at least 1 year beyond an individual's minimum obligated service. It consists of 76 item responses from the SCII (Campbell & Hansen, 1981). Neumann and Abrahams (1978a) reported a biserial correlation of .25 between the SCII career tenure scale and extended service. Scores on this scale can range from 62 to 138.

BQ

This scale was developed in 1981 to predict completion of the NROTC program. It consists of 14 biographical information and personality items that were selected from Rimland's Background Questionnaire (Neumann, Githens, & Abrahams, 1967; Rimland, 1957). Neumann reported a biserial correlation of .12 between the BQ career tenure scale and NROTC attrition. Scores on this scale can range from 93 to 107.

ES

This scale uses 132 item responses from the Strong-Campbell Interest Inventory (Campbell & Hansen, 1981) to identify NROTC applicants with engineering and science interests. Neumann and Abrahams (1978b) reported biserial correlations of .56 and .58 between the engineering and science interest scale and choice of final major for two cross-validation samples. Scores on this scale can range from 31 to 163.

Criteria

Four performance criteria were used individually or in composites for the analyses.

First-year GPA

This measure is the GPA obtained from all college courses that were taken during the first academic year. Grades for individuals who left prior to the end of the first academic year were cumulated to the time the individual left the NROTC program. For each host or cross-enrollment school[1] GPAs were converted to standard scores such that the mean equalled 50 and the standard deviation equalled 10. By standardizing grades, students attending schools with different grading systems may be pooled into a common sample. Standardization was performed only for those schools with two or more NROTC scholarship students attending them. Individuals receiving a standard score of more than five standard deviations below the mean were excluded from the analyses. The extreme scores seemed to have been data-entry errors.

First-year APT

APT is the first-year's GPA in nonacademic military aspects of the NROTC program. Individuals are assigned a grade of 0 to 4.00 by NROTC instructors on each of approximately 20 performance aspects and personal traits (e.g., goal setting, speaking ability, writing ability, personal behavior, maturity, imagination, reliability, initiative, military bearing, and leadership). The grades are averaged to obtain an overall nonacademic military aptitude grade. APT is primarily used to determine how well individuals are adapting to the Navy and NROTC. A similar index used by the United States Naval Academy (Neumann, Mattson, & Abrahams, 1989), has shown moderate relationships to later performance as a commissioned officer. Both the cumulation of APT grades for those individuals who left prior to the end of the first academic year and the standardization of APT were conducted using the same procedures outlined for GPA.

First-year NSG

This measure is the GPA for naval science courses taken during the first academic year. These courses are Navy-relevant academic classes that include subjects such as navigation and seamanship. Students are required to take eight such courses during college, with most students taking one course each semester. The cumulation and standardization of NSGs were conducted using the same procedures outlined for GPA and APT.

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[1]Cross-enrollment school is a college or university which is geographically located near a host institution and uses that host institution's NROTC unit.

TECH

This criterion was developed by categorizing each college major as non-technical (1) (e.g., psychology) or technical (2) (e.g., aeronautics). Appendix A contains the full list of majors and their corresponding categories that were obtained from the Chief of Naval Education and Training (CNET).

Individuals who had TECH scores represented a subset of the larger sample. TECH was considered valid if the candidate had entered college in (1) 1983, 1984, or 1985 or (2) 1986 and had completed at least one semester/quarter of his/her junior year. It was assumed that individuals who had both entered NROTC in 1983-1985 and declared a final major either would have graduated or be far enough along in their course work to complete the degree under the major they had indicated. The same assumption was made for individuals in entering year 1986 who had started their junior year in college.

Procedure

Development and Cross-validation Samples

The sample was split into three subsamples. To generate the first two samples, the 5,957 people who entered NROTC between 1983 and 1986 were randomly assigned to either a development or cross-validation (i.e., hold-out) sample (N = 3,652 and N = 2,305, respectively). The larger proportion of the sample (i.e., 60%) was assigned to the development subsample to maximize the stability of the predictor weights. The third sample, 652 individuals who entered NROTC during 1987, was used as a second cross-validation sample. The second cross-validation was performed to ensure that weights developed on earlier classes remained stable for the most recent year for which criterion data were available.

Developing Optimally Weighted Composites

Validity coefficients corrected for range restriction[2] were used in multiple regression to develop an optimally weighted selection composite for predicting each of the four individual criteria. Although this procedure results in four separate composite scores, to make selection decisions, applicants must ultimately be rank-ordered on a single metric. To obtain such overall composites the single-criterion composites were combined in two different ways. One combination (COMP3) included the composites designed to predict GPA, APT, and NSG, and the other (COMP4) included composites designed to predict all four criteria.[3] Weights were derived for these overall composites by combining predictor weights obtained for the single criterion regression equations. The procedure used to obtain these weights is outlined in Appendix B.

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[2]Because selectees tend to have higher predictor scores than non-selectees, the range of predictor scores is reduced. As a result of this reduced variability, a correlation based on a restricted sample would underestimate the relationship between a predictor and a criterion for the applicant population.

[3]Representatives of the Chief of Naval Education and Training supplied the criterion weights (See Appendix) for the multiple criterion composites.

Each of the composites were then cross-validated on both the 1983-1986 and 1987 hold-out samples. The composites were evaluated for their ability to predict GPA, APT, NSG, and TECH in the 1983-1986 sample, and their ability to predict GPA, APT, and NSG in the 1987 sample.

Developing Experimental Composites

Using the same criterion weights employed in the optimally weighted composites, the same procedure was followed to create two experimental predictor composites. The first experimental predictor composite assessed the contribution of the BQ in predicting the four criteria by eliminating it from the composite and optimally weighting the remaining six predictors. For the second experimental composite, SATM and SATV, respectively, received 70 percent and 30 percent of the total weight assigned to these two variables in the QI-87. The cross-validation of the two experimental composites paralleled that of the optimally weighted composites.

Using Previously Developed Operational Composites

The QI-87 and the OI were also revalidated on the two hold-out samples. Mattson et al. (1986) supplied the b weights that were used to compute the QI-87 and the rational weights that were used to compute the OI.

Determining Effective Weights

To assess the percentage of weight that each predictor received in the various composites, effective weights scaled to 100 percent were computed. Effective weights allow for comparisons (1) within each selection composite to determine which predictors contributed the most weight and (2) between the selection composites to determine if the contribution of each predictor changed depending on the selection composite. To compute the effective weights, the unstandardized b weights for each predictor within a composite were first multiplied by the corresponding standard deviation for that predictor. The products of b times SD were then summed across all the predictors included in the composite. Each product was then divided by that sum and multiplied by 100.

Evaluation of Composites

Tests of statistical significance were not performed in any of the following analyses for two reasons. The primary reason concerns the previously mentioned correction of validity coefficients for range restriction. These corrections were made on individual predictor-criterion correlations before they were used to construct composites for both the developmental and cross-validation samples. While the corrected coefficients provide a more appropriate basis for developing and evaluating the composites, standard statistical tests are not appropriate for assessing the significance of validity coefficients once they have been corrected.

Second, the large subsamples may blur the lines between statistical and practical significance. For example, a zero-order correlation coefficient of $r = .062$ for 1,000 subjects is significant at the .05 level; however, the practical value of a statistically "significant" predictor of this magnitude when used alone may be questioned. Nevertheless, such a predictor may be useful under one or both of the following conditions: (1) when, in combination with other predictors, it provides a

unique contribution to the prediction of the criterion _or_ (2) when large numbers of selection decisions must be made (as is done for NROTC selection).

RESULTS AND DISCUSSION

Development Sample

Table 2 shows the means and standard deviations for the predictors and criteria, and correlations for those two sets of variables. This information is provided for both the entire development sample and the development subsample that had valid scores on the TECH criterion. After corrections for range restriction, validities increased approximately .02 to .03.

Academic Potential of the Average NROTC Applicant

The SATM means indicate that the average NROTC scholarship student scored very high in mathematics aptitude. A SATM score of 642 corresponds to approximately the 89th percentile. In other words, the average NROTC scholarship student outperforms 89 percent of the high school seniors who take the mathematical portion of the SAT (College Entrance Examination Board, 1989). The SATV and HSR means are also above average. For SATV, the average NROTC scholarship student outperforms approximately 87 percent of the college-bound seniors taking that test (College Entrance Examination Board, 1989). Finally, the average NROTC scholarship student had an HSR of 73.55. That HSR value indicates that the average NROTC scholarship recipient graduated in the top 10 percent of his/her high school class (per Table 1).

Comparison of Development Sample and Subsample Findings

There are negligible differences between the predictor and criterion means and standard deviations for the full development sample and its subsample. The intercorrelations among GPA, APT, and NSG are slightly lower for the development subsample than for the full development sample. The three criteria were moderately intercorrelated, with NSG and GPA being the most highly related (.562 in the development sample). This result would be expected because these two criteria measure academic aspects of the NROTC program and college; furthermore, NSG is computed from a subset of the courses included in GPA. These relationships are also consistent with the findings of Mattson et al. (1986). In that study, correlations among the criteria varied from .40 to .54, and GPA and NSG were the most highly intercorrelated of the three criteria. GPA showed the highest relationship with TECH, a criterion not included in earlier selection composites. The correlations between the three criteria and TECH are, however, much smaller than the intercorrelations among GPA, APT, and NSG.

Table 2

Descriptive Statistics for the Full Development Sample and the Development Subsample

Variable	Mean	SD	GPA	APT	NSG	TECH
			Correlations with Criteria			
Predictor						
$SATV_f$	558.51	76.78	.124	.027	.192	---
$SATV_r$	560.08	76.98	.101	.013	.193	-.051
$SATM_f$	642.91	64.35	.187	.036	.092	---
$SATM_r$	642.85	63.99	.183	.047	.054	.221
HSR_f	73.55	16.81	.272	.132	.171	---
HSR_r	74.45	16.34	.280	.105	.156	.093
$INTER_f$	4.82	.48	.035	.093	.019	---
$INTER_r$	4.83	.46	.030	.061	.016	-.008
$SCII_f$	105.36	5.96	-.076	-.010	-.021	---
$SCII_r$	105.49	5.88	-.069	-.008	-.014	.066
BQ_f	100.97	2.32	.007	.047	.067	---
BQ_r	101.09	2.30	-.006	.010	.052	-.030
ES_f	110.19	13.55	.013	.022	.083	---
ES_r	110.62	13.28	.024	.033	.094	.399
Criterion						
GPA_f	49.88	9.66	1.000			
GPA_r	51.72	8.16	1.000			
APT_f	49.71	9.77	.425	1.000		
APT_r	52.15	8.43	.363	1.000		
NSG_f	49.80	9.77	.562	.419	1.000	
NSG_r	51.66	8.57	.546	.363	1.000	
$TECH_f$	---	---	---	---	---	---
$TECH_r$	1.59	.49	.243	.104	.161	1.000

f as a subscript denotes the Full Development Sample ($\underline{N}$ = 3,652).
r as a subscript denotes the Development Subsample ($\underline{N}$ = 2,077).

The predictor-criterion correlations varied little in magnitude between the full development sample and its subsample. For both groups, HSR was the variable most highly correlated with GPA and APT. SATV and HSR showed the strongest relationships with NSG. Although SATM and SATV showed strong relationships with GPA and NSG, respectively, they showed virtually no relationship with APT. The interview rating, however, was related to APT. These latter two sets of findings are consistent with the observation that GPA and NSG measure the academic performance

of NROTC participants while APT measures military characteristics of the future officers. ES was the predictor most highly correlated with TECH. This outcome was expected because the ES scale was specifically developed to predict final major. Finally, SATM also had a moderate association with TECH.

Cross-validation

Predictor scores were computed for each of the nine composites (i.e., the four single-criterion, two multiple-criterion, and two experimental composites, and the QI-87) using data from the hold-out samples. These nine composite scores and the scores obtained on the OI were then correlated with each criterion.

Single-criterion Composites

Table 3 shows the cross-validity coefficients that were obtained for the four single-criterion composites using data from the 1983-1986 and 1987 hold-out samples. The cross-validities for the single-criterion composites are provided principally to show the upper limit of prediction for a given criterion since each composite should predict its own criterion better than any of the other composites. To use the table, the criterion of interest is located in the right-hand columns, and the predictor composite is located in the left-hand column. The cross-validity is found at the intersection of the corresponding column and row. For example, the .122 shown on the first row, second column of Table 3 indicates the cross-validity estimate that was obtained when weights that were derived to optimally predict GPA (for the development sample) were used to predict APT in the 1983-1986 hold-out sample.

Table 3

Cross-validity Coefficients for the Optimal, Single-criterion Composites in the 1983-1986 and 1987 Hold-out Samples

	Criteria			
Variable	GPA	APT	NSG	TECH
GPA_a Composite	**.289**	.122	.237	$.138_c$
GPA_b Composite	.304	-.001	.228	--
APT_a Composite	.219	**.137**	.230	$.108_c$
APT_b Composite	.220	.073	.193	--
NSG_a Composite	.220	.118	**.291**	$.121_c$
NSG_b Composite	.227	.009	.286	--
$TECH_a$ Composite	.102	.036	.137	**$.430_c$**
$TECH_b$ Composite	.124	.056	.063	--

a as a subscript denotes the 1983-1986 Hold-out Sample (N = 2,305).
b as a subscript denotes the 1987 Hold-out Sample (N = 652).
c as a subscript denotes the 1983-1986 Reduced Hold-out Sample (N = 1,313) with a valid TECH score.

Of primary interest are the bold-faced values shown on the diagonal. These values reflect the predictive ability for each composite's target criterion; that is, the GPA composite reveals a cross-validity of .289 with the GPA criterion. These diagonal values may be compared with the four corresponding validities observed for these composites in the developmental sample; .327 for GPA; .175 for APT; .297 for NSG; and .455 for TECH (untabled). As expected, these development-sample validities are, in general, slightly higher than the corresponding cross-validities indicating a modest amount of shrinkage. The GPA, NSG, APT, and TECH composites each predicted its target criterion better than any of the other composites. Surprisingly, the APT composite was a better predictor of GPA and NSG than of APT. Overall, three of the four composites (GPA, APT, and NSG) were better predictors of GPA and NSG than of APT and TECH.

Another important finding is that none of the composites had a meaningful negative relationship with the non-target criteria. Had a negative relationship been observed between any of the predictor composites and NROTC performance criteria, the decision to use the predictor in the selection system would have been problematic. For example, this situation would have occurred if individuals who tend to score high on the GPA composite also tend to have low APT criterion values.

The coefficients obtained on the second cross-validation sample are shown directly under the bold-faced cross-validities. Across all four single-criterion composites, the cross-validities obtained on the 1987 sample varied little from those obtained on the 1983-1986 sample when GPA and NSG were predicted (see Table 3). All of the composites predicted GPA slightly better in the 1987 sample (than in the 1983-1986 sample) and NSG slightly better in the 1983-1986 sample (than in the 1987 sample). Somewhat larger differences were found between the cross-validities obtained for the two samples when predicting APT. The GPA, APT, and NSG composites predicted APT better in the 1983-1986 sample than in the 1987 sample. The APT coefficients were, however, very low in both cases. Further, the cross-validities for the two samples were both near .00 when the TECH-derived composite was used to predict APT. Inspection of the correlations between APT and several highly-weighted predictors (i.e., HSR, SATM, and SATV) revealed higher relationships for the 1983-1986 sample than for the 1987 sample. Thus, the relatively higher validities obtained for the individual predictors in the 1983-1986 sample appeared to account for the subsequent differences in predictive ability for these composites.

Multiple-criterion Composites

Table 4 shows the cross-validity coefficients for the three sets of multiple-criterion composites: optimal, experimental, and operational, that were obtained using data from the 1983-1986 and 1987 hold-out samples. As was found with the composites designed to predict a single criterion, very little difference was detected between the cross-validities obtained on the 1983-1986 and 1987 samples when GPA and NSG were predicted. Also similar to the earlier findings were the pattern of differences between the cross-validities obtained for the two samples when predicting APT. Although all of the cross-validities for APT were very low, the composites predicted APT marginally better in the 1983-1986 sample than in the 1987 sample.

Table 4

Cross-validity Coefficients for the Multiple-criterion and the Operational Composites in the 1983-1986 and 1987 Hold-out Samples

Multiple-criterion and Operational Composites	Criteria			
	GPA	APT	NSG	TECH
Optimal Composites				
$COMP3_a$	.269	.134	.277	.135c
$COMP3_b$	.279	.024	.257	---
$COMP4_a$	.246	.114	.260	.292c
$COMP4_b$	.259	.037	.221	---
Experimental Composites				
$Experimental\ 1_a$ (no BQ)	.246	.110	.253	.297c
$Experimental\ 1_b$ (no BQ)	.257	.019	.232	---
$Experimental\ 2_a$ (SATM 70%/SATV 30%)	.245	.114	.259	.292c
$Experimental\ 2_b$ (SATM 70%/SATV 30%)	.257	.038	.220	---
Operational Composites				
$Quality\ Index_a$ (87)	.274	.137	.251	.107c
$Quality\ Index_b$ (87)	.278	.024	.228	---
$Overall\ Index_a$	.194	.102	.205	.090
$Overall\ Index_b$	---d	---d	---d	---d

[a] As a subscript denotes the 1983-1986 Hold-out Sample (N = 2,305).
[b] As a subscript denotes the 1987 Hold-out Sample (N = 652).
[c] As a subscript denotes the 1983-1986 Reduced Hold-out Sample (N = 1,313) with a valid TECH score.
[d] Since the OI was discontinued after the 1986 selection cycle, scores for this composite were not available for the 1987 cross-validation sample.

The majority of the composites were better predictors of GPA and NSG than of APT and TECH. Although the magnitudes of the cross-validities were slightly higher in the Mattson et al. (1986) study (many of the validities fell above .30), the two studies revealed the same pattern of results. Interestingly, three (COMP4 and Experimental 1 and 2) of the six composites produced higher validities when predicting TECH than when predicting GPA, APT, or NSG. Considering the findings for all of the criteria, it appears that for both samples the COMP4 and the two experimental composites would be the most useful for simultaneously predicting all four performance criteria.

The similarity between the validities for the Experimental 1 and the COMP4 composites, was expected since the two composites are the same except that the Experimental 1 composite does not include the BQ. Because the BQ was designed to predict officer tenure and showed little relationship to college criteria, its exclusion had little impact. On the other hand, elimination of the BQ may relate to a length of service criterion.

The validities for the Experimental 2 and the COMP4 composites were also very similar, showing that the 70 percent-30 percent forced weighting of SATM and SATV scores had little effect. This result is largely due to the fact that the forced weights for these variables were very close to the optimal weights (SATM 69% to SATV 31%) derived for the COMP4.

Comparisons between the validities for the COMP4 and the previously developed operational composites indicate that both the COMP4 and the QI-87 are superior to the OI in predicting each of the four criteria. The differences between the COMP4 composite and the QI-87 in predicting GPA, APT, and NSG are slight; whereas, the differences between these two composites when predicting TECH clearly favor the COMP4. This advantage for the COMP4 is partially due to the fact that the development of the COMP4 included TECH as a criterion and is, therefore, more valid than the QI-87 for predicting this criterion.

Effective Weights

Table 5 shows the effective weights for each of the predictors included in the different selection composites. Overall, HSR received the highest weight in the majority of the composites. SATM and the newly added ES also received relatively high weights for several of the composites. Comparisons of the effective weights for the COMP4 with those of the two operational composites provide possible explanations for the differences in cross-validities among these composites for predicting each of the criteria. One reason concerns the addition of ES as a predictor in the COMP4. Because ES is highly correlated with TECH and received a large weight, it made the COMP4 a much stronger predictor of TECH and somewhat less valid for predicting GPA and APT. Two additional differences are the COMP4's decreased emphasis on HSR and its use of optimal weights for SATM and SATV. In contrast, the QI-87 assigns a much higher weight to HSR and equal weights to SATM and SATV.

In summary, the COMP4 composite assigns optimal weights to SATV and SATM, includes ES in the selection composite, reduces the weight given to HSR, and includes TECH as an additional criterion. These differences slightly lowered the predictability of GPA and APT ($COMP4_{GPA}$ $\underline{r}$ = .246 versus QI-87 $\underline{r}$ = .274) ($COMP4_{APT}$ $\underline{r}$ = .114 versus QI-87 $\underline{r}$ = .137), slightly increased the ability to predict NSG ($COMP4_{NSG}$ $\underline{r}$ = .260 versus QI-87 $\underline{r}$ = .251), and substantially improved the ability to predict TECH ($COMP4_{TECH}$ $\underline{r}$ = .292 versus QI-87 $\underline{r}$ = .107).

Modifying Effective Weights

Revision 1

Based on the results, the COMP4 and the two experimental composites were determined to be the most potentially useful prediction systems for NROTC scholarship selection when attempting to predict all four criteria. It should be noted that although the GPA predictor composite is just as effective for predicting GPA, APT, NSG as the three composites just mentioned, the desire to improve the prediction of technical major resulted in the choice of COMP4 and the two experimental composites as potentially useful selection systems. An examination of the effective weights, however, revealed that the ES score received a higher percentage (approximately 24%) of the total weight than CNET desired. The magnitude of the ES weight was primarily due to the large criterion weight assigned to TECH (.25) in the criterion composite. To indirectly lower the percentage of total weight received by ES, the weight assigned to the TECH criterion was reduced from .25 to .10. The remaining criteria were then reweighted as follows: GPA, .40; APT, .30; and NSG, .20.

Table 5

Effective Weights for Predictors in Different Selection Composites

Variable the Composite was Originally Designed to Predict	Predictors						
	SATV	SATM	HSR	INTER	SCII	BQ	ES
Optimal Single-criterion Composites							
GPA	11	28	58	4	0	2	-1
APT	3	2	44	27	4	13	7
NSG	36	-2	28	1	9	12	16
TECH	-25	45	13	2	8	-1	58
Optimal Multiple-criterion Composites							
COMP3	17	10	42	8	5	9	9
COMP4	8	18	33	6	6	5	24
Experimental Composites							
Experimental 1 (no BQ)	9	19	35	7	6		24
Experimental 2 (SATM 70%/SATV 30%)	7	16	35	6	5	6	25
Operational Composites							
Quality Index (87)	11	11	55	11	9	3	--
Overall Index	<----20[a]---->		40	10	<----30[b]---->		--

[a] An effective weight of 20 was applied to the sum of SATV and SATM.
[b] An effective weight of 30 was applied to the sum of SCII and BQ.

The proposed change in criterion weights required the development of new composites. Predictor weights for the three new composites were calculated in the same manner described previously, using the new criterion weights. The predictor weights were then cross-validated on the 1983-1986 and the 1987 samples. The resulting cross-validities appear in Table 6. Comparisons between Table 6 and Table 4 show that reducing the weight of TECH in the three composites resulted in an increased ability to predict GPA, APT, and NSG in the 1983-1986 sample, and GPA and NSG in the 1987 sample. These increases in predictive ability were accompanied by decreases in the ability to predict TECH. The cross-validities that were obtained when the COMP4 and Experimental 1 and 2 composites were used to predict TECH with the initial criterion weights ranged from .292 to .297; whereas, the cross-validities ranged from .204 to .214 when the revised set of criterion weights were used.

It was also necessary to compare the cross-validities (from Table 6) for the three revised composites with the QI-87 cross-validities (from Table 4). Although all four composites predicted GPA, APT, and NSG equally well, the COMP4(R) and the two revised experimental composites remained better predictors of TECH (than did the QI-87), even with the reduction in weight assigned to TECH. The new effective weights for the COMP4(R) and the two experimental revised composites appear in Table 7. Tables 5 and 7 show that the effective weight assigned to ES in each revised composite has been reduced by approximately half. For example, the effective weight for ES in the COMP4 was 24 percent. After the change in criterion weights, the effective weight for ES was reduced to 13 percent.

Table 6

Cross-validities for Revision 1 and Revision 2

Revised Composites	GPA	APT	NSG	TECH
	Criteria			
Revision 1				
$COMP4(R)_a$	.271	.128	.269	$.204_c$
$COMP4(R)_b$	.283	.027	.243	---
$Experimental\ 1(R)_a$	.271	.123	.261	$.209_c$
$Experimental\ 1(R)_b$	.282	.016	.235	---
$Experimental\ 2(R)_a$	.271	.127	.260	$.214_c$
$Experimental\ 2(R)_b$	.283	.032	.232	---
Revision 2				
$Experimental\ 3\ (no\ ES)_a$	.282	.126	.246	$.141_c$
$Experimental\ 3\ (no\ ES)_b$	.296	.011	.238	---

a as a subscript denotes the 1983-1986 Hold-out Sample (N = 2,305).
b as a subscript denotes the 1987 Hold-out Sample (N = 652).
c as a subscript denotes the 1983-1986 Reduced Hold-out Sample (N = 1,313) with a valid TECH score.

Table 7

Effective Weights for Revision 1 and Revision 2

Revised Composites	SATV	SATM	HSR	INTER	SCII	BQ	ES
	Predictors						
Revision 1							
COMP4(R)	12	16	41	8	6	6	13
Experimental 1(R)	13	16	43	9	5	-	14
Experimental 2(R)	8	19	44	8	4	7	13
Revision 2							
Experimental 3 (no ES)	10	25	47	8	4	6	-

Revision 2

Despite the large reduction in weight assigned to ES, it continued to receive a higher than desired weight. The CNET representatives were concerned that applicants with outstanding credentials might not receive NROTC scholarships if their interests tended toward non-technical fields of study. To correct this problem, the ES was eliminated from the predictor composite entirely. To retain its usefulness for selection, CNET officials requested that ES scores be converted to a 20-point scale. For this purpose, raw ES scores were transformed, via linear interpolation, to an adjusted scale ranging from 0 to 20. This transformation was accomplished by the following equation:

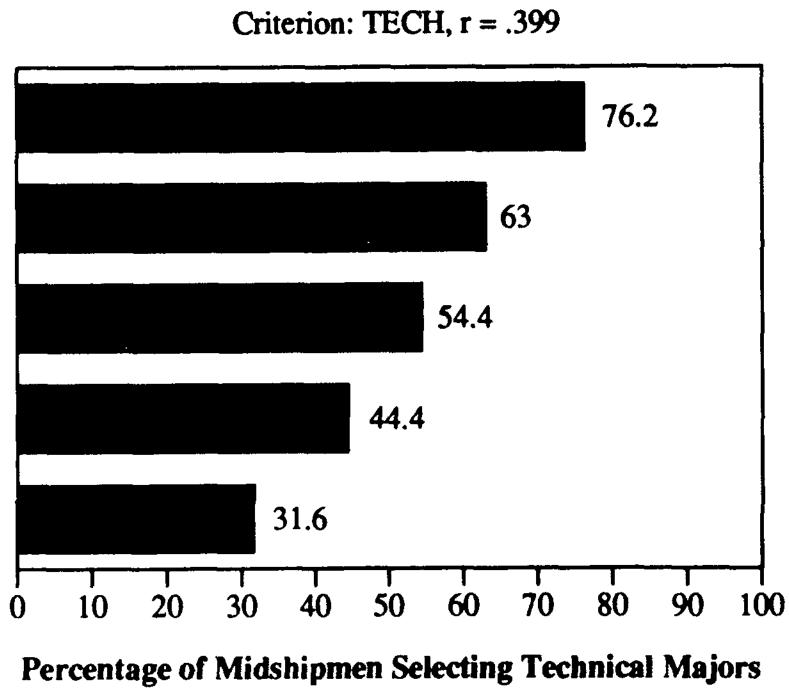
$$\text{Adjusted ES Score} = (\text{Raw ES Score} \times .1961) - 10.1972$$

Using the adjusted score range, an expectancy table was constructed (on the development subsample) for use in interpreting an individual's ES score. The expectancy table is shown in Figure 1. To use the table, an individual's transformed ES score is located in the table, and the likelihood of that individual selecting a technical final major can be determined.

Removal of ES from the predictor composite required the redistribution of its effective weight (13%) to the remaining six predictors. Using the effective weights from COMP4(R), CNET representatives created Experimental 3 (No ES) by adding 9 percentage points to SATM, adding 6 percentage points to HSR, and reducing SATV by 2 percentage points; the weights assigned to INTER, SCII, and BQ remained the same as in the COMP4(R) composite. The effective weights for Experimental 3 (no ES) composite appear in the bottom row of Table 7. As shown, the weight that was assigned to ES was redistributed so that SATM and SATV received additional weight but remained at approximately a 70-30 ratio. The computing (i.e., $\underline{b}$) weights for the six remaining predictors were .0585 for SATV, .1676 for SATM, 1.0386 for HSR, 4.7730 for INTER, .2875 for SCII, and 1.1264 for BQ.

The cross-validities for the Experimental 3 composite appear in Table 6. As shown, the Experimental 3 composite predicted GPA as well as the COMP4(R), the QI-87, and the two previously revised experimental composites. The Experimental 3 composite also resulted in cross-validities for APT and NSG that were comparable to those obtained for the four multiple- riterion composites just mentioned. As a result of removing ES, the cross-validity for TECH fell below that of the COMP4(R) and the two experimental composites. The Experimental 3 composite did, however, remain a better predictor of TECH than was the QI-87 (see Table 4).

Adjusted ES Score	Raw ES Score	Category
13.5309 thru 20	121 and above	Upper 20%
12.1582 thru 13.3348	114 thru 120	Next 20%
10.7855 thru 11.9621	107 thru 113	Mid 20%
9.0206 thru 10.5894	89 thru 106	Next 20%
0 thru 8.8245	97 and below	Lower 20%



Note. Anyone receiving an adjusted ES score below 0 should be assigned a score of 0.
Anyone receiving an adjusted ES score above 20 should be assigned a score of 20.

Figure 1. Expected percentage of midshipmen selecting technical majors based on ES score (entering years 1983 to 1986).

PRACTICAL IMPLICATIONS

Figure 2 illustrates the practical impact of replacing the QI-87 with the Experimental 3 composite, hereafter referred to as the QI-89. Figures 2a through 2c show the expected percentage of midshipmen who will earn above average GPAs, APTs, and NSGs, respectively, after 1 year of college. These percentages are based on the cross-validities obtained on the 1983-1986 hold-out sample. The figures suggest that the percentage of midshipmen earning above average grades is virtually the same whether the QI-87 or the QI-89 is used. Figure 2d shows the expected percentage of midshipmen who will select a technical major given their score on TECH. This latter figure indicates that the percentage of individuals selecting a technical major can be increased by using the QI-89 as opposed to the QI-87.

Adoption of the QI-89 would increase the ability to predict TECH without decreasing the ability to predict the remaining three criteria. In addition, the QI-89 would provide the flexibility that is necessary when evaluating individual applicants. More specifically, the selection board could utilize the ES scale in scholarship selection without being required to assign it a specific percentage of the total selection points. Thus, the possibility of excluding individuals simply because they scored low on the ES scale is avoided. In essence, an individual's score on the other six predictors can be summed first, using the weights obtained in the regression procedure, and then his/her transformed ES score can be considered by the selection board.

Equating QI-89 Scores to Previous QI Scores

After computing QI-89, the score is transformed, via linear transformation, to a scale with a M and SD similar to that of previous years. QI-87 scores may range from approximately 0 to 300 whereas the unadjusted QI-89 scores may range from approximately 0 to 450. QI-89 scores are transformed to the QI-87 scale with the following equation:

$$\text{Adjusted QI-89} = (\text{Raw QI-89 Score} \times .7786) - 43.0058$$

This transformation allows selection boards to compare QI scores across years without changing the validity of QI-89. That is, this transformation places the QI-89 on the same scale as the QI- 87 to provide consistent interpretation of scores from year to year.

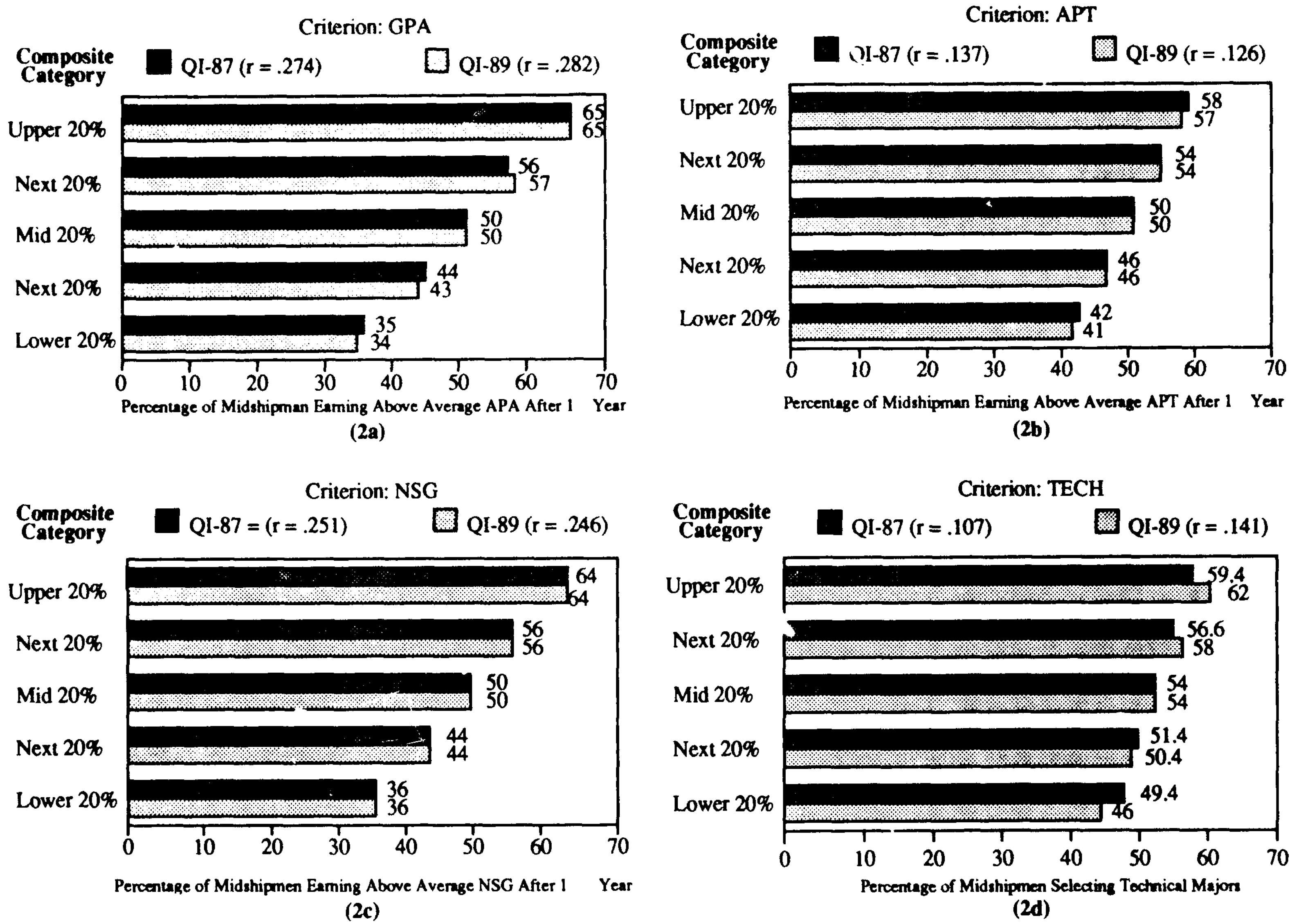


**Figure 2. Expected percentages for entering years 1983 to 1986--
Comparisons between the current QI-87 and the revised QI-89.**

SUMMARY AND CONCLUSIONS

1. All of the multiple-criterion predictor composites except the OI resulted in similar cross-validities when predicting GPA and NSG. When predicting TECH, the cross-validities for the predictor composites varied a great deal. As expected, those composites that included TECH as a criterion were, in fact, more valid for predicting TECH than were the predictor composites without TECH. All composites resulted in low cross-validities for the criterion APT, including the composites specifically designed to predict APT.

2. Regardless of whether SATM and SATV were weighted optimally, equally, or in a ratio of 70-30, the composite validities were similar when predicting GPA and NSG. Composites that either optimally weighted SATM and SATV or weighted SATM 70 percent and SATV 30 percent were, however, more valid for predicting TECH. The latter findings were expected since SATM was the better predictor of TECH (than was SATV).

3. The exclusion of the BQ in the experimental composite had little impact on the cross-validities for any criterion.

4. Overall, a newly developed prediction system (QI-89) predicted GPA, NSG, and APT as well as or slightly better than the other predictor composites. The QI-89 can also be used in conjunction with the ES expectancy table to influence the proportion of NROTC scholarship recipients choosing technical majors.

RECOMMENDATIONS

1. CNET should use the QI-89 and the ES scale as aids in selecting future NROTC scholarship applicants.

2. CNET should re-evaluate the QI-89 as component predictors are modified and improved.

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APPENDIX A

TECHNICAL AND NON-TECHNICAL MAJORS

TECHNICAL AND NON-TECHNICAL MAJORS

Note: The number located to the left of each major is the code given to the particular major in the NROTC database.

Technical

Physical Sciences

36 Operations Research/Systems Analysis (N); Operations Analysis; Computer Operations Analysis
37 Meteorology; Climatology; Aerology
38 Chemistry (other than biochemistry); Wood Technology
39 Biochemistry
40 Ceramics; Ceramics Engineering
42 Metallurgy
43 Mathematics; Computer Science (Math Oriented)
44 Physics
45 Astronomy
46 Physical Sciences not elsewhere classified

Engineering and Architecture

47 Civil Engineering, General
48 Agricultural Engineering
50 Safety Engineering; Fire Protection Engineering
51 Naval Architecture; Marine Engineering
52 Nuclear Engineering
53 Ordnance Engineering, General and Industrial (N); Weapons Systems, General (N); Ordnance Systems Engineering, General (N)
54 Engineering, Industrial/Management/Commercial
55 Chemical Engineering
56 Electrical Engineering, General
57 Mechanical Engineering, General
58 Textile Engineering; Textile Technology
59 Electronics Engineering
60 Communications; Radio Engineering; Command Communications (N); Applied Communications (N); Communications Engineering (N) not elsewhere classified
61 Aeronautical Engineering
62 Mining Engineering
63 Petroleum Engineering
64 Metallurgical Engineering
65 Architecture; Architectural Engineering; Landscape Architecture; Regional/City Planning
66 Engineering; Architecture; Computer Science Engineering; Engineering and Architecture topics

Social Sciences

90 Statistics

Technical Majors (not listed in above categories)

0A Aeronautics
0B Aerospace Engineering
0C Electrical Power Engineering
0D Materials Engineering
0E Ocean Engineering
0F Petrochemical Engineering
0G Systems Engineering

Non-technical

General

00 Liberal Arts

Agriculture and Forestry

01 Agriculture, General
02 Husbandry, Poultry and Animal
03 Husbandry, Dairy; Dairy Technology
04 Horticulture
05 Agronomy; Soil Science
06 Forestry
07 Range Science
08 Agriculture and Forestry, n.e.c. (Wildlife Management)
09 Sciences, General/Natural/Composite/Basic; Environmental Science

Biological Science

10 Biological Sciences; General; Limnology; Pre-medicine; Marine Biology, Pre-Dental; Pre-Veterinary
11 Botany, General
12 Bacteriology; Microbiology; Virology
13 Animal Genetics
14 Physiology
15 Zoology; Fish and Game Management; Ichthyology
16 Entomology
17 Parasitology; Helminthology; Nematology
19 Biological Sciences, n.e.c.

Medical Sciences

20 Medicine and Surgery
21 Pharmacy
22 Public Health; Sanitation
3 Dentistry; Dental Surgery
24 Nursing
25 Optometry/Physiological Optics
26 Veterinary Science
27 Pharmacology
28 Osteopathy
31 Anatomy
32 Pathology
33 Medical Science, n.e.c. (Mortuary Science; Medical Biology, Medical Biology, Medical Technology)

Physical Sciences

34 Geology; Paleontology; Petrology; Geological Engineering
35 Nautical Science; Naval Science; Maritime Academy Curricula

Social Sciences

67 International Relations; International Law; Foreign Affairs; Foreign Area Studies
68 Political Science
69 Public Administration; Police Administration; Municipal Government
70 Industrial Arts
71 History; American Studies
72 Industrial Management
73 Personnel Administration (N) (may be used when other than Navy - Sponsored)
74 Psychology
75 Anthropology; Ethnology
76 Archeology
77 Economics
78 Accounting
79 Geography
80 Business Economics; Commercial Education; Secretarial Education
81 Business Administration; Advertising; Commerce; Foreign Trade; Marketing; Management; computer related Business Administration
82 Banking; Finance
83 Merchandising; Retailing
84 Physical Education
85 Education (used when education is a major field of study; degrees based on a teaching major in a particular subject field (English, Biology, etc.) are coded as degrees in the field itself)
86 Home Economics

87 Journalism
88 Law
89 Library Science
91 Social Work; Social Welfare Administration
92 Social Sciences, n.e.c. (Sociology; Criminology, Pre-Law)

Art and Classics

93 Advertising Art; Dancing; Drama (Theater); Fine Arts; Industrial Design; Music; Printing; Sculpture
94 English Language; English Literature
95 Classical Languages and Literature
96 Modern Languages and Literature
97 Theology; Divinity; Religion (professional ministerial curricula)
98 Philosophy; Religion (nonsectarian)
99 Not a major field; used for special education reports prepared in BUPERS

APPENDIX B

COMPUTATION OF b WEIGHTS FOR A COMPOSITE CRITERION

COMPUTATION OF B WEIGHTS FOR A COMPOSITE CRITERION

Computation of b weights for an equation predicting a composite criterion requires five steps. To illustrate that process, the steps required to derive the b weight for SATV in predicting COMP4 follow. First, unstandardized b weights were obtained for each of the four individual criteria. For each criterion, all seven predictors were forced into the multiple-regression equation. Second, the b weight for SATV and the standard deviation for the criterion were extracted from each of the four sets of analyses. Third, each b weight was divided by the standard deviation of the criterion for which it had been used as a predictor. Fourth, the resulting quotient was multiplied by a CNET-supplied weight: .30 for GPA, .25 for APT, .20 for NSG, and .25 for TECH. Those weights corresponded to the relative emphasis that CNET placed on each criterion. Fifth, the products for the four criteria were then added to produce the unstandardized weight given to SATV in the prediction of the COMP4 ($b_{v(G,A,N,T)}$). That calculation is depicted by the following formula:

$$b_{v(G,A,N,T)} = [(b_G / SD_G)(.30)] + [(b_A / SD_A)(.25)] + [(b_N / SD_N)(.20)] + [(b_T / SD_T)(.25)]$$

where b_G is the unstandardized weight given to SATV in the equation to predict GPA; b_A is the unstandardized weight given to SATV in the equation to predict APT; b_N is the unstandardized weight given to SATV in the equation to predict NSG; and b_T is the unstandardized weight given to SATV in the equation to predict TECH. SD_G is the standard deviation for GPA; SD_A is the standard deviation for APT; SD_N is the standard deviation for NSG; and SD_T is the standard deviation for TECH. The same steps were followed to compute the unstandardized weights that were assigned to the other six variables used to predict the COMP4. The computation of the COMP3 followed all the steps outlined above, except for step four. The criteria in COMP3 were unweighted; therefore, each b weight was not multiplied by the criterion weights obtained from CNET.